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Ultrasound image guided radiotherapy for prostate cancer using a transperineal probe

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Purpose/Objective: Pre-treatment imaging based on ultrasound (US) images was first developed using transabdominal probes but several issues linked to image quality and probe pressure[1] were reported. The aim of this work was to evaluate a non-invasive transperineal (TP) US probe comparing its registration results with cone beam CT (CBCT) on patients treated for a prostate cancer, with prostate in situ or after prostatectomy.

Materials and Methods: 10 prostate patients (cohort A) and 14 post-prostatectomy patients (cohort B) were imaged with the TP probe (Clarity, Elekta), which acquires 3D images using an automated motorized sweep. During the planning CT session, a reference US (US_{ref}) image was acquired with the patient in the same position as that of the CT acquisition. A reference positioning volume (RPV) was delineated on the US_{ref} image (Figure 1). For each treatment session, a daily US (US_{day}) image was acquired and manually registered on the US_{ref} image using a RPV projection. A CBCT image was acquired right after and registered on the reference CT. The differences between CBCT and TP-US shifts were analysed on 320 and 453 paired US_{day}/US_{ref} and CBCT/CT images for the cohorts A and B, respectively. Finally, the systematic difference found between CBCT and US shifts was retrospectively calculated on the first 5 sessions and applied to the US shifts of the following sessions.

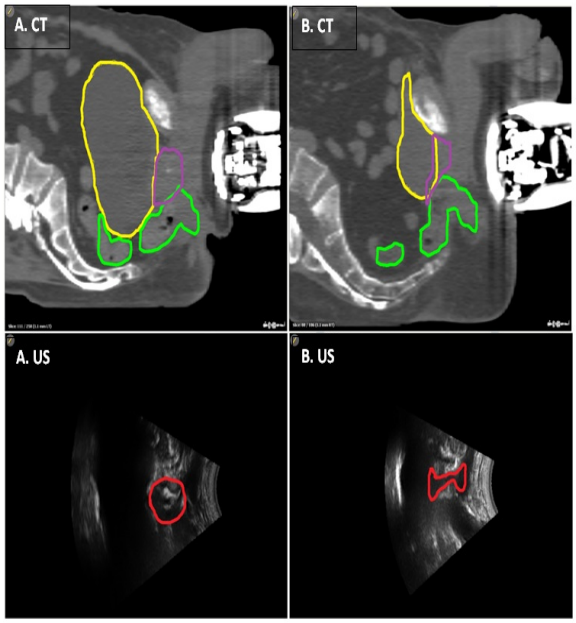

Figure 1: CT and US images of patients treated with in situ prostate (A), and after a prostatectomy (B). Volumes: purple: CTV; red: RPV; yellow: bladder; green: rectum. The RPV corresponds to the prostate volume, for patient A and to the bladder neck plus the urethra, for patient B.

Results: The US system was well tolerated by the patients. All images were of good quality for the registration of the two cohorts. On the raw data, shifts agreements at ± 5 mm were above 80 %, with the best agreement obtained in the lateral direction for both localizations (≥ 97.6 %). Average differences between the 2 modalities were 2.2 ± 3.2 mm, -0.2 ± 2.5 mm and -0.3 ± 2.7 mm for the cohort A, and 1.5 ± 2.6 mm, -1.6 ± 3.2 mm and -0.5 ± 2.3 mm for the cohort B, in the axial, longitudinal and lateral directions respectively. These results were comparable to other inter modalities, e.g., CBCT soft tissue registration versus fiducial markers with MV-EPI registration[2]. Correcting the systematic shifts between the 2 image modalities on the base of the first 5 fractions enabled the percentage of agreement to be greater than 93 % for all directions and localizations and the average differences to be close to 0 mm (≤ 0.3 mm whatever the direction or localization). Therefore, correcting systematic shifts drastically improved the results.

Conclusions: TP-US based localization of the prostate or the prostate bed is a feasible method to ensure accurate delivery of treatment plans. This device represents an attractive alternative to invasive and/or irradiating imaging modalities.

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Beam delivery time reduction in breath-hold treatments for left-sided breast cancer using FFF technique

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